Drought Effects on the Availability of Spawning Habitat for Fall-run Chinook Salmon in the Tuolumne River Watershed

by Emma Davidson, Kaycey Bui and Robert Arlen

Introduction

The main run of Chinook Salmon (*Oncorhynchus tshawytscha)* of the Tuolumne watershed is the Fall run. These fish enter the streams in early fall and spawn from October through December in the Tuolumne River below La Grange Dam. Much of the historic spawning habitat of the salmon has been lost due to anthropogenic activity, mainly the building of dams. With the drought conditions of 2012-2015, this loss in habitat has been exacerbated. Drought is a prolonged period of time in which there is extremely low water inflow and availability (Lake, 2003). The current drought is considered supra-seasonal, persisting beyond a season and continuing to decrease in precipitation and water availability (Lake, 2003). Decreased precipitation leads to lower water levels and consequently fewer available spawning sites. Drought-reduced seasonal flows disrupt habitat conditions along the Tuolumne River, decreasing the availability of spawning sites. Data from 1992 through 2004 from the Lodi Fish and Wildlife office show a 62% decline, despite restoration efforts, among Chinook Salmon in the San Joaquin River basin, one of the largest decreases among the Central Valley populations. Based on past declines, one could expect extended drought conditions to have a negative impact on the already-declining Fall run Chinook Salmon in the Tuolumne River. As such, there are many options available that may aid in restoring much of the lost habitat, such as gravel augmentation, adjusting flow regime, and releasing water from La Grange dam during key periods of time for salmon spawning.

Spawning Requirements

Chinook salmon are anadromous fish native to California. These fish are semelparous, meaning they have a single spawning event during their lifetime, dying shortly after. The west coast has multiple populations of Chinook, but this paper will focus on the Central Valley populations found in the Tuolumne River watershed. Similar to the life cycle of other salmonids, the Chinook of the Central Valley population is dominated by the Fall run. Adult Fall run Chinook Salmon return to their natal streams July through December and begin to spawn between October to the end of December (Healey, 1991). At this time the salmon are between 2-6 years old. When females return to their natal sites to spawn they begin by selecting an optimal site to create their redd. They turn their bodies to the side and use strong sweeping movements of their tail to remove substrate and form a shallow cavity. The removed substrate forms a pile downstream of the cavity and is referred to as the tailspill. The female will then lay her eggs and dig out more cavities to lay her remaining four or five pockets of eggs—the entirety of this area is the redd.

The main characteristic females are searching for are coarse gravel deposition with enough subgravel flow to properly aerate the eggs. The method females use to dig their nests not only allow flow from the surface water to percolate the eggs but also groundwater to flow over the eggs and provide them with oxygen (Geist, 1998). Because Chinook have relatively large eggs, they have a low surface area to volume ratio and obtaining enough oxygen from surrounding water flow for the embryo is a priority (Healey, 1991). This oxygenation requirement could lend to why Chinook highly prefer and aggregate in certain areas to spawn, while avoiding areas with seemingly similar

habitat qualities. The requirement for sub-gravel flow supports the idea that spawning habitat is limited and many females may already spawn in poor quality areas resulting in higher egg mortality due to asphyxiation. With the reduction of water levels due to drought, the availability of optimal habitat is expected to decrease, leading to more females spawning in poorer habitat and resulting in increased egg mortality. Semelparity and relatively long life cycles (up to 8 years) of Chinook can offset the negative effects of a severe drought on a population.

Drought effects on Sediment Transport and Hydrology

Dams, reservoirs, and powerhouses constructed along the Tuolumne River since the 1850s alter natural streamflow and migration of the Chinook salmon. The free-flowing river that once fostered seasonal fluvial processes now experiences regulated flow regimes to accommodate human water use. Historical records document Chinook spawning sites far upstream to Preston Falls in the Tuolumne River. Since the erection of the La Grange dam, however, Chinook Salmon are restricted to about one-third of their original spawning range (McBain & Trush, 2000).

La Grange not only blocks the Chinook Fall run, it also traps upstream coarse sediment particles, which are necessary material for downstream Chinook redds (McBain & Trush, 2000). By impeding the transport of coarse-grained sediments, the reservoir also prevents the replenishment of spawning habitat bed materials. Despite the reservoir-induced sediment choke along the river, scouring downstream continues and annually produces more sediment. Although these erosion events support Chinook spawning ability, they rely on regulated reservoir releases which are often dictated by annual precipitation rates.

Confined to the lower reaches of the Tuolumne River and dependent on the flows controlled by the NDP reservoir, spawning Chinook salmon often struggle to find suitable redd sites. Drought restricts downstream releases from the New Don Pedro reservoir which reduce the levels of transport, scouring and rebuilding of alluvial deposits. When spawning habitats are limited, Chinook sometimes bury established redds to make room for their own - a process known as superimposition. Redd superimposition due to limited habitat availability threatens reproductive success of Chinook salmon, especially when flows are low in times of drought (McBain & Trush, 2000).

Drought Effects on Spawning Habitat Availability

Supra-seasonal drought has negative impacts on Chinook Salmon spawning habitat availability below La Grange dam. Lower water levels during drought years lead to a reduction in habitat by drying of marginal areas of the stream (Lake, 2003). As water output decreases, stream level lowers, exposing more of the riverbed and decreasing the overall percentage of the riverbed that is covered in water. Lower water levels may also increase daily temperature fluctuations. Both the lower water levels and increased fluctuations in temperature lead to fewer suitable habitats for spawning. As drought conditions persist or worsen, spawning habitat for Fall run Chinook Salmon below La Grange will continue to decrease in both quality and quantity. Reduced sediment transport impedes salmon ability to build redds by increasing fine sediment deposition and decreasing sediment sorting, reducing or eliminating the variety of sediment needed to build redds and provide adequate dissolved oxygen to eggs. If the drought continues to worsen, there will be less water available for everyone, humans and salmon alike.

Mitigation

Despite natural drought conditions, there are ways to help mitigate its effects. Gravel augmentation might help to ameliorate the loss of sediment deposition and transportation in years of extreme drought, when reduced flows reduce the ability of the stream to transport sediment (Riebe et al. 2014). Mimicking a natural flow regime is important for salmon spawning as there needs to be enough water present at key times during the year for the salmon to reproduce successfully. Releasing additional water from La Grange would help restore many dried up backwater channels that may be ideal for spawning (McBain & Trush, 2000). Increasing discharge from La Grange and replenishing sediments downstream of the dam would help counteract the loss of spawning habitat that comes from extended drought conditions.

Works Cited

Burner, Clifford J. "Characteristics of Spawning Nests of Columbia River Salmon." *Fishery Bulletin of the Fish and Wildlife Service* 52 (1951): n. pag. *Native Fish Lab*. Web. 30 May 2015.

Geist, David R., and Dennis D. Dauble. "Redd Site Selection and Spawning Habitat Use by Fall Chinook Salmon: The Importance of Geomorphic Features in Large Rivers." *Environmental Management* 22.5 (1998): 655-69. Web.

Healey, M. C. "Life History of Chinook Salmon." *Pacific Salmon Life Histories*. By C. Groot and L. Margolis. Vancouver: UBC, 1991. N. pag. Print.

Lake, P. S. "Ecological Effects of Perturbation by Drought in Flowing Waters." Freshwater Biology Freshwater Biol 48.7 (2003): 1161-172. Web.

McBain & Trush. “Habitat Restoration Plan for the Lower Tuolumne River Corridor.” *Final Report - Prepared for the Tuolumne River Technical Advisory Committee* (March 2000) http://www.fws.gov/lodi/afrp/documents/tuolplan2.pdf

Riebe, C. S., L. S. Sklar, B. T. Overstreet, and J. K. Wooster (2014), Optimal reproduction in salmon spawning substrates linked to grain size and fish length, Water Resour. Res., 50, 898–918, doi:10.1002/2013WR014231.